

Advanced Human Health Risk Assessment Methodology for Sites with Contaminated Sediment

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Sites with Contaminated Sediments

- Challenging to Study
 - Physical settings
 - Human use factors
- Challenging to Remediate
 - Limited technologies
 - Questionable effectiveness
 - High costs

Human Exposure Pathways

- Dermal contact with water
- Dermal contact with sediments
- Ingestion of water
- Ingestion of sediments
- Inhalation of volatile chemicals
- **Consumption of fish and/or shellfish**

Exposure Assessment Alternatives

- Default exposure factors in point-estimate assessment
- Site-specific data in point-estimate assessment
- Site-specific data in probabilistic (Monte Carlo) assessment
- Site-specific data to predict exposure using event-by-event probabilistic techniques

Data Collection to Support Risk Assessment

- Site-specific data essential
 - Physical
 - Chemical
 - Biological
 - **Human Use**

Point Estimate Exposure Assessment

- Fixed exposure factor values for behavior
- Fixed environmental concentrations
- Single values represent entire exposure period
- Estimate long-term average dose

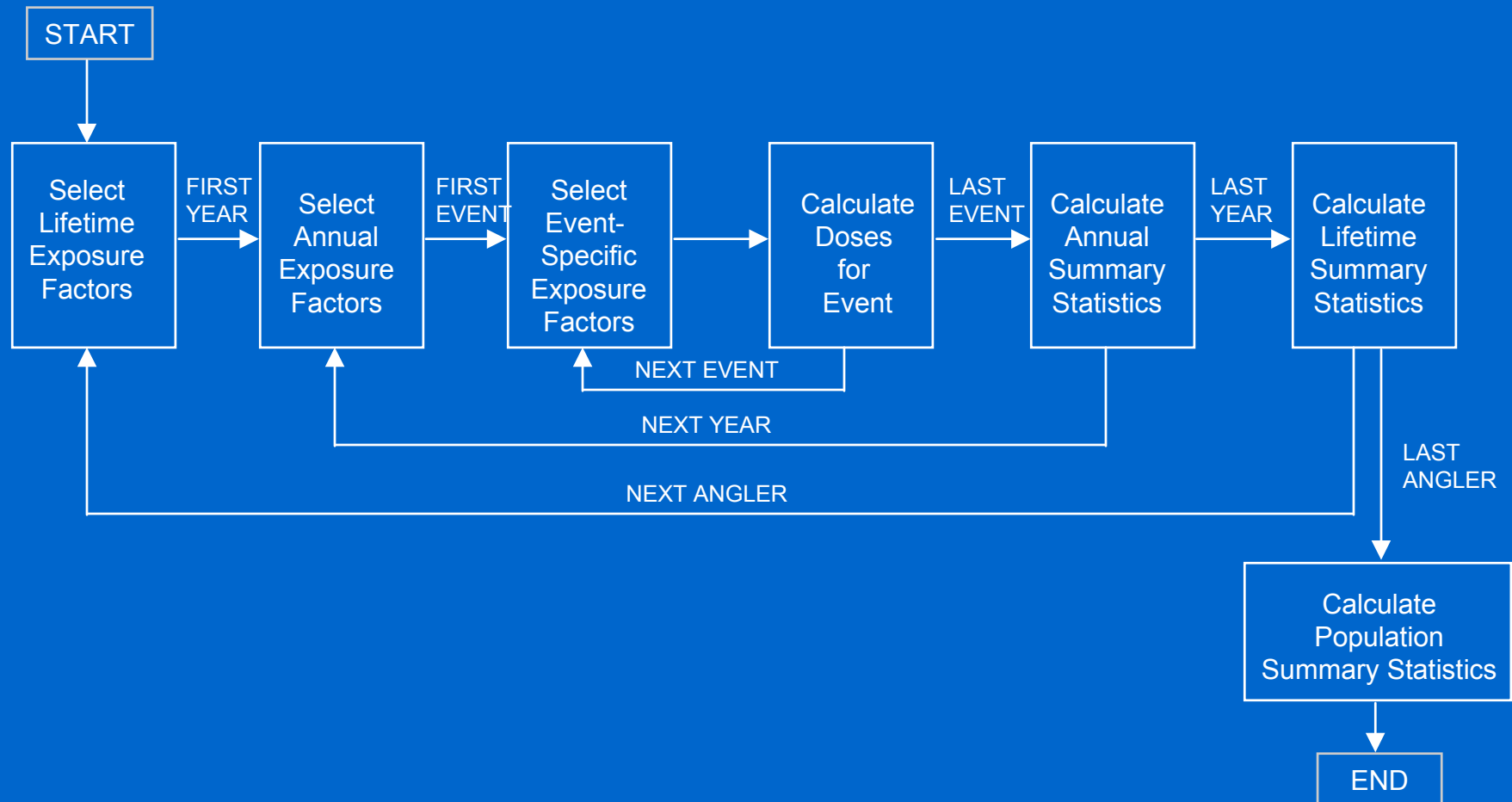
Standard Monte Carlo Approach

- Same underlying equations and type of “answer” as point estimate approach
- Probability distributions for exposure factor values
- Behavior and concentration vary from individual to individual
- Limited ability to represent correlation between exposure factors

Event-by-Event Monte Carlo Exposure Assessment

- Same underlying equations and type of “answer”
- Discretization of lifetime exposure into individual “events”
- Different time-scales for different exposure factors
- Explicitly consider influence of covariables
- Probability distributions for exposure factor values
- Behavior and concentrations vary
 - From individual to individual
 - Within exposure period for each individual

Structure of Event-by-Event Analysis for Fish Consumption Exposure Assessment



Key Advantages

- Maximum and consistent use of site-specific data accounts for
 - Seasonal changes in activity and species availability
 - Interrelation of exposure factors
- Match data time-scale to exposure time-scale
- Flexible, realistic exposure scenarios
- High end exposure reflects realistic combination of exposure factors

Key Challenges

- Providing appropriate site-specific data
- Determining time-step for distribution changes
- Model coding and verification

Case Studies

- Hudson River, NY
- Sangamo-Weston Site (Lake Hartwell), SC
- Palos Verdes Shelf, CA

Hudson River, NY - Background

- Limited application of technique
- No site-specific data on fish consumption
- Annual changes in concentrations in fish
- Age-dependent changes in body weight
- Exposure duration based on fishing duration and probability of relocation or death

Hudson River, NY - Results

- Non-cancer hazard and cancer risk estimates comparable to point-estimate results
- Consequence of limited application of technique

Sangamo-Weston Site, SC - Background

- Site-specific fish consumption data
- Annual changes in concentrations in fish
- Age-dependent changes in fish consumption rate and body weight
- Epochs of 5 to 11 years
- Exposure duration via probability of moving or dying at end of each epoch

Sangamo-Weston Site, SC - Results

- Risk estimates approximately one order of magnitude lower than point estimate and typical Monte Carlo methods
- Time-dependent concentration term most influential exposure factor

Palos Verdes Shelf, CA - Background

- Extensive local data
- Annual variation
 - Body weight, seasons fished, trips per season
- Trip-by-trip variation
 - Destination, trip success, species combinations
 - Chemical concentrations, consumption rates
- Exposure duration from local data on fishing duration

Palos Verdes Shelf, CA - Results

- Risk estimates approximately three orders of magnitude lower than point estimate and standard Monte Carlo methods
- Validated by agreement with other local fishing and consumption studies
- Key was portrayal of realistic scenario
 - Location preferences
 - Species preferences
 - Seasonal changes

Summary

- Fish/shellfish consumption is human health risk driver
- Site-specific data equally important for human behavior and site characterization
- Event-by-event methods present opportunity to minimize uncertainty, inform cleanup decisions